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A PROGRAM TO PRODUCE STANDARD SHEWHART CONTROL CHARTS
FOR THE STATISTICS. (U) FLORIDA UNIV GAINESVILLE DEPT
OF INDUSTRIAL AND SYSTEMS ENGIN. J E KING ET AL.

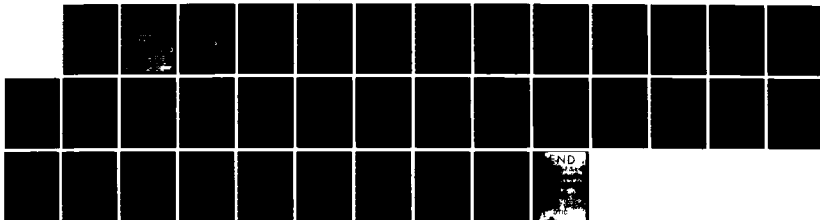
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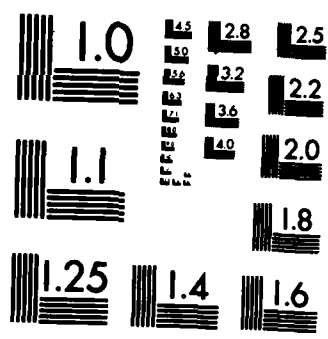
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CONTROL CHARTS FOR THE STATISTICS
X-BAR AND R OR S, P, NP, C, OR U

Research Report No. 84-31

by

Judith E. King
and
Richard S. Leavenworth

RESEARCH REPORT

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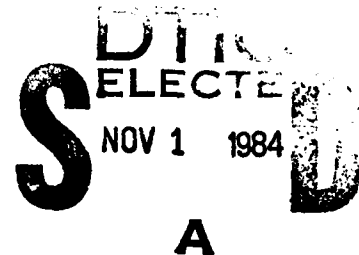
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Accession For	
DATE	CHART
TIME	CHART
Location	
<i>Little on file</i>	
Distribution/	
Availability Codes	
Cost	Avail and/or
	Special
<i>A1</i>	

ABSTRACT

This report presents an interactive Fortran 77 computer program for developing and plotting standard Shewhart control charts for \bar{X} -bar and R or s, p, np, c or u. It was developed on a VAX 11/750 computer using the VMS operating system. Central lines and control limits may be based on the input data, modifications of input data, or standard values. Input data is stored in separate named files so that it may be recalled, modified, or added to.

USERS GUIDE

Before Running Program

All data must be stored in a permanent data file. The name of the data file is limited to 10 characters.

X-bar, R, and S charts

This data must be stored in a data file with one subgroup per line with a space or a comma between each value. The maximum number of subgroups is 30, and the maximum subgroup size is 10. The maximum data value permitted is 9999.99.

P Charts

This data must be stored in a data file in the order number inspected, number rejected, separated by a comma or a space. The maximum number of data pairs is 30. The maximum data value permitted is 9999.99.

U Charts

This data must be stored in a data file in the order number of nonconformities, number produced, separated by a comma or a space. The maximum data value permitted is 9999.99.

NP and C Charts

This data must be stored in a data file with data values separated by a space or a comma. The maximum number of data points is 30. The maximum data value permitted is 9999.99.

If previously used control limits are going to be used, then they must be stored in a permanent data file. They must be stored in the order-upper control limit, lower control limit, central line, separated by a space or a comma. If both X-bar and R (S) control limits are to be used, they must be stored in separate files.

Running the Program

There are 2 basic menus in this program. The first menu is only shown once. It gives the user a choice of charts. If the user should wish to change the type of chart, the program will have to be run again. This menu gives the user a choice between: 1) X-bar and R charts, 2) X-bar and S charts, 3) C or U charts, 4) P or NP charts. The user makes his/her choice by entering the number associated with the option and hitting the carriage return.

After this choice has been made, the user will have to enter the names of the data file and output file. These names are limited to 10 characters.

X-bar, R, S Charts

The user must enter the number of subgroups and the subgroup size. These values must be limited to 30 and 10, respectively. The name of the X-bar and R (S) control limit files must also be supplied. Even if these files do not exist at this time, the user is still required to enter a name for them in case, during the run of this program, a decision is made to save current control limits.

P and NP Charts

If the user chooses this as the first option, he/she must then enter a 1 if working with fraction rejected or 2 if working with number rejected. The user must also give the name of the control limit file (limit 10 characters). The number of lots inspected must be entered and, if using the NP chart, the lot size must also be given.

C and U Charts

If the user chooses this as the first option, he/she must then enter a 1 if working with number of nonconformities, or a 2 if working with nonconformities per unit. The number of data points (pairs) must be entered along with the name of the control limit file.

All of the above information (and future information) will be requested by the computer in the form of a written prompt which will appear on the screen. The user must wait for the prompt before entering the information.

After the previous information has been entered, a second menu will appear on the screen. This menu will vary according to the type of chart chosen in the first menu. All options are listed below plus any information that the user will need to enter.

Options

Hardcopy of Data

A copy of the raw data and the points plotted on the charts will be written to the output file.

Histogram

This option will only appear if the user choose X-bar and R (S) charts in the first menu. The user will have to decide if the histogram will appear on the screen, written to the output file, or both. The number of cell intervals will also have to be entered. If the histogram is viewed on the screen, the user will have to enter a 1 to continue the program.

Control Chart

If the user is running a P chart, then he/she has a choice between using individual lot sizes, estimated average lot size, or calculated average lot size.

All charts give the option of using control limits calculated from data, old control limits, or aimed at values, except in the case of np (individual lot sizes) charts or U charts which do not give the option for using old control limits. In the latter case, the central line of a previous control chart could be entered as an aimed at value. If aimed at values are chosen, these must be entered by the user.

Charts can be viewed on the screen, written to a file or both. The control limits can also be saved for future use. Out of control points are indicated by a question mark.

Add More Data

The user must enter the number of new data points (or subgroups). This number is limited to 30. The permanent data file will be altered to reflect the change in data. If the total number of data points (old and new) is greater than 30, some of the beginning data points will be deleted to make room for the new ones.

Delete Data Points

This option allows the user to delete data points from the calculation of control limits. The user must give the total number of data points to be deleted and the number of each point to be deleted. Once this is done, the control chart is automatically calculated, so the user will have the same options listed under Control Chart. These deleted points will be plotted on the chart. The user should choose to have the control charts calculated from data or else the influence of the deleted points will not be shown.

Exit Program

This option ends the program. To obtain a hardcopy of everything written to the output file, the user should type PRINT (filename).

INTRODUCTION

The following program is an interactive program designed for the development of X-bar and R or S, P, NP, C, and U charts. The program features options that enable the user to analyze data using standard Shewhart quality control procedures. Options include a histogram, the ability to delete points from the calculation of control limits, and the ability to add new points. Output from this program (excluding hardcopy of the data) can be viewed on the screen and all can be stored in a data file to be printed out after the program run is finished. This program is written in Fortran 77 and was implemented on a Vax 11/750 computer. It is intended as an instructional tool and as a research tool for analyzing process data.

DESCRIPTION OF PROGRAM

MAIN PROGRAM

The basic function of the main program is to identify the type of data being used, read the data from an external data file, and to call the appropriate subroutines depending on the options specified by the user.

The first menu is the main program identifies the type of data being used. This menu will only be displayed once during a run of the program, so if the user wishes to change the type of data being used, the program will have to be run again. The choices offered in the first menu are: (1) X-bar and R charts; (2) X-bar and S charts; (3) C or U charts; (4) P or NP charts.

Some information will have to be entered by the user from the terminal. This information includes the name of the data file, the name of the output file, the name of the control limit file (except in the case of a u chart),

the subgroup size and the number of subgroups (in the case of X-bar and R or X-bar and S charts), and the number of data points (for all other charts). The data will then be read from the external data file.

The second menu then will appear on the screen and the options will vary according to the type of data being used. Once an option is chosen, subroutines corresponding to these options are called and executed. When the option is completed, this second menu is again displayed.

OPTIONS

Hardcopy of data

This option will give the user a copy of the current data set and the values of the points which are to be plotted on the control chart. If the data type being used corresponds to a C chart or an NP chart, then just the subroutines to print a hardcopy of the data is called. If any other type of data is used, then the first subroutine called is the one that calculates the values of the points that will be plotted on the control chart. This subroutine then returns to the main program and the corresponding subroutine to print a hardcopy of the data is called. All this information is written to the output file named by the user, and a hardcopy can be obtained after the user has finished running the program.

Histogram

This option will yield a histogram either printed on the terminal screen or written to the output file or both. This option is only available if variables data are being used to prepare X-bar and R charts or X-bar and S charts. When this option is completed, the second menu will appear on the screen.

Control Chart

In general, this option will plot a control chart on the terminal screen or write it to the output file, or both. No matter which control chart is requested, three subroutines are called to produce the control chart. First, a subroutine is called to calculate all values needed to compute the control limits. These values are then passed to a subroutine that calculates the control limits and these values, along with the points to be plotted, are passed to the subroutine that prints out the charts. When this option is completed, the second menu again will appear on the screen.

Adding new subroutines/Adding more data

These options enable the user to alter the data currently being used. A subroutine corresponding to the type of data being used is called. The user enters the new data from the terminal. The external data file is altered to accomodate the new data as is the current data array in the program. When this option is completed, the second menu is displayed on the screen.

Deleting data points

This option enables the user to alter the values of the control limits by eliminating points from the calculation of the control limits. These points are NOT deleted from the current data array in the program or from the external data file. The first subroutine called calculates the data used in the calculation of the control limits using all the data points. The next subroutine called alters these calculation to reflect the change introduced by the deletion of points. These altered values are then passed to the subroutine that calculates the control limits and the points to be plotted are

then passed to the subroutine that plots the control charts. When the option is finished, the second menu will appear on the screen.

Exit Program

This option ends the program. The user can then obtain a hardcopy of the output file which will contain everything that was written to the file (i.e. hardcopy of data, histogram and/or control charts as applicable and as requested).

In the above sections, the options and the various subroutines connected with them were described in general. Each subroutine now is described in detail.

DESCRIPTION OF SUBROUTINES

Subroutine CRDXRS, CRDPU, CRDNPC

These three subroutines take care of the intermediate calculations needed to compute control limits. They are called not only when a control chart is requested, but also when a hardcopy of the data is needed, and when data points are to be deleted from control limit calculations.

Subroutine CRDXRS

This subroutine performs calculations on subgroup data. The raw data, the number of subgroups and the subgroup size is passed to the subroutine. The average and arange (std. dev.) of each subgroup, the grand average (over all subgroups), the average range (std.dev.) are passed back to the main program.

Subroutine CRDPU

This subroutine is called to perform calculation on data dealing with the number rejected and number inspected, or the number of nonconformities and the number produced. The raw data and the number of data points are passed to this subroutine. For each pair of data points, either the fraction rejected or the number of nonconformities per unit is calculated. The average fraction rejected or the average nonconformities per unit is calculated.

If the data being used deals with the number rejected and the number inspected, then the user has a choice of using individual lot sizes, estimated average lot size, or a calculated average lot size. If the user chooses a calculated average lot size, then this value is calculated. If the user chooses to use an estimated average lot size, then the user is asked to enter this value from the terminal. All this new information is passed back to the main program for future use.

Subroutine CRDNPC

This subroutine does intermediate calculations for data consisting of the number rejected or the number of nonconformities. The number rejected (nonconformities), the number of data points, and in the case of data dealing with nonconformities, the lot size is passed to this subroutine. The average number rejected (average number of nonconformities) is calculated. If the data used is the number rejected, then the average fraction rejected is calculated. All this new data is passed back to the main program.

Subroutines CLXRS,CLPNPC,CLPC

These subroutines take the calculations passed to the main program from CRDXRS, CRDPU, and CRDNPC and calculate the upper and lower control limits and the central line of the control chart.

Subroutine CLXRS

This subroutine calculates the control limits for the X-bar, R, and S charts. The average of X-bar over all the subgroups, the average range (std. dev.), the subgroup size, and the number of subgroups are passed to this subroutine. The user is given the choice of having the control limits calculated from the data, using old control limits, or using aimed at values. If the user chooses to have the control limits calculated from data, then these are calculated. If the user chooses to use old control limits, then these are read in from the control limit data file, the name of which was asked for at the beginning of the main program. If aimed at values for X-bar and sigma are to be used, the user is required to enter these values from the terminal and then the control limits are calculated. The control limits along with the data passed in are passed back to the main program.

Subroutine CLPNPC

This subroutine is used to calculate the control limits for the np chart or the c chart or the p chart if an average lot size is being used. The values of np-bar and p-bar or c-bar are passed to this subroutine. The user is given the option of having control limits calculated from the data, using old control limits or using aimed at values. If aimed at values are being used, the user is asked to enter them from the terminal. The control limits are then calculated the same as if the original data were being used. If old control limits are being used, then they are read in from the control limit

file the user already set up. The control limits are then passed back to the main program.

Subroutine CLPC

This subroutine calculates the control limits for the u chart or the p chart (if using individual lot sizes). The values of \bar{u} or \bar{p} and the number of data points and the number produced or the number inspected are passed to this subroutine. The user is given the option of having the control limits calculated from data or using aimed at values. Old control limits are not used here since the control limits depend on the number produced or the number inspected for each data point. If the user chooses to use aimed at values, then he or she is asked to enter this value from the terminal. Then the control limits for each pair of data points are calculated and passed back to the main program.

Subroutine Chart

This subroutine plots the control chart for \bar{X} , R, s, p, np, and c. The points to be plotted, the control limits, and the number of points are passed to this subroutine. The user is given the option of displaying the chart on the screen, writing it to the output file, or both.

Basically, no matter which chart is to be printed, the procedure is the same. The upper and lower control limits and the central line are placed at specific locations on the chart. The points to be plotted are then scaled between the upper and lower control limits. If a point falls above the upper control limit or below the lower control limit, that point is indicated by a question mark. If it falls in control, an asterisk is used. The values of the upper and lower control limits and the central line are printed on the

chart. The user is given the option of saving the values of the central line and control limits in the control limit file named in the main program.

Subroutine UCHART

This subroutine displays the u or p chart (individual lot sizes). The user is given the option of viewing the control chart on the screen or having it written to the output file or both. The values for each set of upper and lower control limits, the central line, and the points to be plotted are passed to this subroutine. This subroutine is basically the same as Subroutine CHART, except that all values are scaled between the highest valued upper control limit and the lowest valued lower control limit. If a point falls outside its control limits, it is indicated on the chart by a question mark. Otherwise, the point is plotted as an asterisk. The user is not given the option of saving these control limits as they are dependent on the lot sizes (number produced). If the user wishes to use the value of the central line again, he or she can use it as an aimed at value in a future run.

Subroutine DELXRS,DELPU,DELNPC

These subroutines are used to delete points from the calculation of control limits. These data points are not deleted from the permanent data file or the current data array used by the program.

Subroutine DELXRS

This subroutine deletes points from the X-bar, R, or s charts. The average of each subgroup and the range (std. dev.) of each subgroup, the number of subgroups, the overall average and the average range (std. dev.) are passed to the program. The user is asked to enter the total number of subgroups to be deleted. The sum total of the averages of all the subgroups

and the sum total of the ranges (std. dev.) of all the subgroups are then calculated. The user is asked to enter (one at a time) the number of the subgroup to be deleted. The average and range (std. dev.) of the deleted subgroups are then subtracted from the sum totals and the new overall average and average of the range (std. dev.) is calculated. The only values that change then are the average of the subgroup averages and the average of the ranges (std. devs.). Consequently, when the chart is printed out, all data values will be plotted.

Subroutine DELPU

This subroutine deletes points from p or u chart. The number rejected or the number of nonconformities, the number inspected or the number produced, the average fraction rejected or the average nonconformities per unit and the number of data points are passed to this subroutine. The user is asked to enter the total number of pairs of data points to be deleted. The total number inspected or the total number produced and the total number rejected or the total number of nonconformities are calculated. The user is asked to enter (one at a time) the number of the data pair to be deleted. These values are then subtracted from the respective totals and the new value of \bar{p} or \bar{u} is calculated and passed back to the main program.

Subroutine DELCNP

This subroutine deletes points from the np or c chart. The number rejected or the number of nonconformities, the average rejected or the average number of nonconformities and in the case of the NP chart, the average fraction rejected and the lot size are passed to this subroutine. The user is asked to enter the total number of data points to be deleted. The total number rejected or the total number of nonconformities is calculated. The

user is then asked to enter the number of the data point to be deleted. The values of these data points are then subtracted from their respective totals and the new values for the average rejected and the average fraction rejected or the average nonconformities are passed back to the main program.

Subroutines ADDXRS, ADDPU, ADDNPC

These subroutines allow the user to add new data points to the existing data file. These points also are added to the permanent data file.

Subroutine ADDXRS

This subroutine adds new data to existing subgroup data. The current data array, the number of subgroups, the subgroup size, and the name of the permanent data file are passed to this subroutine. The user is asked to enter the number of subgroups to be added. If the number of current data points plus the number of new data points is greater than 30, then enough subgroups are deleted from the beginning of the file to make room for the new ones and the remaining data points are moved up to the beginning of the file. The user is then asked to enter each subgroup (one at a time). These values are added to the current data file and the permanent one. The number of subgroups is also updated. These new values are passed back to the main program.

Subroutine ADDPU

This subroutine allows the user to add new data points to the data for the P chart and the U chart. The number rejected (number of nonconformities) and the number inspected (number produced) and the number of data pairs are passed to this subroutine. The user is asked to enter the number of pairs of data points to be added. If the total number of data points (old and new) is greater than 30, then the beginning data points will be deleted to make room

for the new ones. The user will then be asked to enter the new data points and these will be added to the current data arrays and the permanent data file.

Subroutine ADDNPC

This subroutine allows the user to add new data points to the data for the np and c charts. The number rejected or the number of nonconformities and the current number of data points are passed to this subroutine. The user is asked to enter the number of data points to be added. If the total number of data points (old and new) is greater than 30, then enough of the beginning data points will be deleted to make room for the new ones. The user will then be asked to enter the new data points and these will be added to the current data array and the permanent data file.

Subroutines HCDXRS, HCDPU, HCD CNP

These subroutines write to the permanent output data file a copy of the raw data and any intermediate values that are used in plotting control charts, namely the values of the points that are plotted. The user can obtain a hardcopy of this data when the program is completed.

Subroutine HISTO

This subroutine plots a histogram of the data used for X-bar and R or s charts. The raw data, the number of subgroups, and the subgroup size is passed to the subroutine. The user is then asked to input the number of cell intervals wanted. The number of cell midpoints and the number in each cell are then calculated and the histogram is printed out. Each row of asterisks in a cell corresponds to one observation unless otherwise indicated by the scale on the side of the histogram.

CONCLUSION

This program is user friendly and with little instruction can be used by anyone with a little knowledge in the field of Quality Control. All of the options are designed to be run independently. This causes some redundancy with regard to the number of subroutines called, but offers the user maximum flexibility when running the program.

The Appendix provides a listing of the computer code.

APPENDIX

```

C
C*** MAIN PROGRAM
C*** THIS IS AN INTERACTIVE PROGRAM DESIGNED TO AID
C*** IN THE DEVELOPMENT OF X-BAR, R, S, C, U, P, AND NP CONTROL
C*** CHARTS
C
      DIMENSION D(30,10), XBAR(30), RANGE(30), SIGMA(30)
      DIMENSION U(30), VUCL(30), VLCL(30), P(30)
      REAL NI(30), NR(30), NC(30), NP(30), NPB
      INTEGER SS
      REAL LCL
      CHARACTER*10 NAME1, NAME2, NAME3, NAME4
C
C*** DISPLAY FIRST MENU
C
      WRITE(3,1)
      1 FORMAT('1', ///, 10X, 'MENU', ///)
      WRITE(3,*) '1) X-BAR AND RANGE CHARTS'
      WRITE(3,*) '2) X-BAR AND S CHARTS'
      WRITE(3,*) '3) C AND U CHARTS'
      WRITE(3,*) '4) P AND NP CHARTS'
      READ(3,*) MENU1
C
C*** READ IN DATA
C
      WRITE(3,*) 'ENTER THE NAME OF YOUR DATA FILE'
      1 ((= 10 CHARACTERS))
      READ(3,3) NAME1
      3 FORMAT(A)
      WRITE(3,*) 'ENTER THE NAME OF YOUR OUTPUT FILE'
      2 ((= 10 CHARACTERS))
      READ(3,3) NAME2
      OPEN(UNIT=1, FILE=NAME1, STATUS='OLD')
      OPEN(UNIT=2, FILE=NAME2, STATUS='NEW')
      IF(MENU1.EQ.1.OR.MENU1.EQ.2) THEN
        WRITE(3,*) 'ENTER THE NUMBER OF SUBGROUPS'
        READ(3,*) NS
        WRITE(3,*) 'ENTER THE SUBGROUP SIZE'
        READ(3,*) SS
        READ(1,*) ((D(I,J), J=1,SS), I=1,NS)
        CLOSE(UNIT=1, STATUS='KEEP')
        WRITE(3,*) 'ENTER THE NAME OF XBAR CONTROL'
        1 LIMIT FILE ((= 10 CHARACTERS))
        READ(3,3) NAME3
        IF(MENU1.EQ.1) THEN
          WRITE(3,*) 'ENTER THE NAME OF RANGE CONTROL'
          1 LIMIT FILE ((= 10 CHARACTERS))
          READ(3,3) NAME4
        ELSE
          WRITE(3,*) 'ENTER THE NAME OF SIGMA CONTROL'
          1 LIMIT FILE ((= 10 CHARACTERS))
          READ(3,3) NAME4
        ENDIF
      ELSEIF(MENU1.EQ.4) THEN
        WRITE(3,*) 'ENTER 1 IF WORKING WITH FRACTION'
        1 REJECTED (P)
        WRITE(3,*) 'ENTER 2 IF WORKING WITH NUMBER'
        1 REJECTED (NP)
        READ(3,*) NNP
        WRITE(3,*) 'ENTER THE # OF LOTS INSPECTED'
        READ(3,*) NL
        IF(NNP.EQ.1) THEN
          WRITE(3,*) 'ENTER THE NAME OF CONTROL LIMIT FILE'
          READ(3,3) NAME3
          DO 10 I=1, NL
            READ(1,*) NI(I), NR(I)
            CONTINUE
        ELSE
          WRITE(3,*) 'ENTER THE LOT SIZE'
          READ(3,*) LS
          DO 20 I=1, NL
            READ(1,*) NR(I)
            CONTINUE
        ENDIF
      ELSEIF(MENU1.EQ.3) THEN
        WRITE(3,*) 'ENTER 1 IF WORKING WITH # OF'
        1 NONCONFORMITIES (C)
        WRITE(3,*) 'ENTER 2 IF WORKING WITH NONCONFORMITIES'
        1 PER UNIT (U)
        READ(3,*) MCU
        WRITE(3,*) 'ENTER THE NUMBER OF DATA POINTS'
        READ(3,*) N

```



```

      CALL CHART(XBAR, UCL, LCL, CL, NS, NAME3, MENU1, MENU2,
      MNP, MCU, *45)
      ELSEIF(MDEL.EQ.1.AND.MENU1.EQ.2) THEN
      CALL CRDXRS(D, NS, SS, XBAR, SIGMA, XBB, SIGB, MENU1)
      CALL DELXRS(XBAR, SIGMA, NS, XBB, SIGB, MENU1)
      CALL CLXRS(MENU1, MENU2, XBB, SIGB, NS, SS, UCL, LCL,
      CL, NAME3)
      CALL CHART(XBAR, UCL, LCL, CL, NS, NAME3, MENU1, MENU2,
      O, O, *45)
      ELSEIF(MDEL.EQ.2.AND.MENU1.EQ.1) THEN
      CALL CRDXRS(D, NS, SS, XBAR, RANGE, XBB, RANB, MENU1)
      CALL DELXRS(XBAR, RANGE, NS, XBB, RANB, MENU1)
      CALL CLXRS(MENU1, MENU2, XBB, RANB, NS, SS, UCL, LCL,
      CL, NAME4)
      CALL CHART(RANGE, UCL, LCL, CL, NS, NAME4, MENU1, MENU2,
      O, O, *45)
      ELSEIF(MDEL.EQ.2.AND.MENU1.EQ.2) THEN
      CALL CRDXRS(D, NS, SS, XBAR, SIGMA, XBB, SIGB, MENU1)
      CALL DELXRS(XBAR, SIGMA, NS, XBB, SIGB, MENU1)
      CALL CLXRS(MENU1, MENU2, XBB, SIGB, NS, SS, UCL, LCL,
      CL, NAME4)
      CALL CHART(SIGMA, UCL, LCL, CL, NS, NAME4, MENU1, MENU2,
      O, O, *45)
      ENDIF
      ELSEIF(MENU2.EQ.7) THEN
      GO TO 1000
      ENDIF
C*** DISPLAY SECOND MENU
C
      ELSEIF(MENU1.EQ.3.OR.MENU1.EQ.4) THEN
      WRITE(5,60)
      60  FORMAT('1', ///, 'MENU', /)
      WRITE(5,*) '1) HARDCOPY OF DATA'
      IF(MENU1.EQ.4) THEN
      IF(MNP.EQ.1) THEN
      WRITE(5,*) '2) P CHART'
      ELSE
      WRITE(5,*) '2) NP CHART'
      ENDIF
      ELSE
      IF(MCU.EQ.1) THEN
      WRITE(5,*) '2) C CHART'
      ELSE
      WRITE(5,*) '2) U CHART'
      ENDIF
      ENDIF
      WRITE(5,*) '3) ADD MORE DATA'
      WRITE(5,*) '4) DELETE DATA'
      WRITE(5,*) '5) EXIT PROGRAM'
      READ(5,*) MENU2
C
C*** CALL APPROPRIATE SUBROUTINE ACCORDING TO OPTION CHOSEN
C
      IF(MENU2.EQ.1) THEN
      IF(MENU1.EQ.3.AND.MCU.EQ.1) THEN
      CALL HCDGNP(NC, N, O, *45)
      ELSEIF(MENU1.EQ.3.AND.MCU.EQ.2) THEN
      CALL CRDPU(NC, NP, N, MENU1, U, UB, O, O, MENU2)
      CALL HCDPU(NC, NP, U, N, MENU1, *45)
      ELSEIF(MENU1.EQ.4.AND.MNP.EQ.1) THEN
      CALL CRDPU(NR, NI, NL, MENU1, P, PB, MENP, ALS, MENU2)
      CALL HCDPU(NR, NI, P, NL, MENU1, *45)
      ELSEIF(MENU1.EQ.4.AND.MNP.EQ.2) THEN
      CALL HCDGNP(NR, NL, LS, *45)
      ENDIF
      ELSEIF(MENU2.EQ.2.AND.MENU1.EQ.3) THEN
      IF(MCU.EQ.1) THEN
      CALL CRDNP(NC, N, O, ANC, O)
      CALL CLPNPC(MENU1, O, ANC, O, UCL, LCL, CL, NAME3)
      CALL CHART(NC, UCL, LCL, CL, N, NAME3, MENU1,
      MENU2, O, MCU, *45)
      ELSE
      CALL CRDPU(NC, NP, N, MENU1, U, UB, O, O, MENU2)
      CALL CLPU(MENU1, N, NP, UB, VUCL, VLCL, CL)
      CALL UCHART(U, VUCL, VLCL, CL, N, MENU1, *45)
      ENDIF
      ELSEIF(MENU2.EQ.2.AND.MENU1.EQ.4) THEN
      IF(MNP.EQ.1) THEN
      CALL CRDPU(NR, NI, NL, MENU1, P, PB, MENP, ALS, MENU2)
      IF(MENP.EQ.1) THEN
      CALL CLPU(MENU1, NL, NI, PB, VUCL, VLCL, CL)
      CALL UCHART(P, VUCL, VLCL, CL, NL, MENU1, *45)

```

```

        ELSE
            CALL CLPNPC(MENU1, MNP, PB, ALS, UCL, LCL, CL, NAME3)
            CALL CHART(P, UCL, LCL, CL, NL, NAME3, MENU1,
                MENU2, MNP, O, *45)
        ENDIF
    ELSE
        CALL CRDNPC(NR, NL, LS, NPB, PB)
        CALL CLPNPC(MENU1, MNP, PB, NPB, UCL, LCL, CL, NAME3)
        CALL CHART(NR, UCL, LCL, CL, NL, NAME3, MENU1,
            MENU2, MNP, O, *45)
    ENDIF
ELSEIF(MENU2.EQ.3.AND.MENU1.EQ.3) THEN
    IF(MCU.EQ.1) THEN
        CALL ADDCNP(NC, N, NAME1, *45)
    ELSE
        CALL ADDPU(NC, NP, N, MENU1, NAME1, *45)
    ENDIF
ELSEIF(MENU2.EQ.3.AND.MENU1.EQ.4) THEN
    IF(MNP.EQ.1) THEN
        CALL ADDPU(NR, NI, NL, MENU1, NAME1, *45)
    ELSE
        CALL ADDCNP(NR, NL, NAME1, *45)
    ENDIF
ELSEIF(MENU2.EQ.4.AND.MENU1.EQ.3) THEN
    IF(MCU.EQ.1) THEN
        CALL CRDNPC(NC, N, O, ANC, O)
        CALL DELCNP(NC, ANC, O, N, O)
        CALL CLPNPC(MENU1, O, ANC, O, UCL, LCL, CL, NAME3)
        CALL CHART(NC, UCL, LCL, CL, N, NAME3, MENU1,
            MENU2, O, MCU, *45)
    ELSE
        CALL CRDPU(NC, NP, N, MENU1, U, UB, O, O, MENU2)
        CALL DELPU(NC, ANC, NP, N)
        CALL CLPU(MENU1, N, NP, UB, VUCL, VLCL, CL)
        CALL UCHART(U, VUCL, VLCL, CL, N, MENU1, *45)
    ENDIF
ELSEIF(MENU2.EQ.4.AND.MENU1.EQ.4) THEN
    IF(MNP.EQ.1) THEN
        CALL CRDPU(NR, NI, NL, MENU1, P, PB, MENP, ALS, MENU2)
        CALL DELPU(NR, PB, NI, NL)
        IF(MENP.EQ.1) THEN
            CALL CLPU(MENU1, NL, NI, PB, VUCL, VLCL, CL)
            CALL UCHART(P, VUCL, VLCL, CL, NL, MENU1, *45)
        ELSE
            CALL CLPNPC(MENU1, MNP, PB, ALS, UCL, LCL, CL)
            CALL CHART(P, UCL, LCL, CL, NL, NAME3, MENU1,
                MENU2, MNP, O, *45)
        ENDIF
    ELSE
        CALL CRDNPC(NR, NL, LS, NPB, PB)
        CALL DELCNP(NR, NPB, PB, NL, LS)
        CALL CLPNPC(MENU1, MNP, PB, NPB, UCL, LCL, CL, NAME3)
        CALL CHART(NR, UCL, LCL, CL, NL, NAME3, MENU1,
            MENU2, MNP, O, *45)
    ENDIF
ELSEIF(MENU2.EQ.5) THEN
    GO TO 1000
ENDIF
1000 ENDIF
STOP
END
C*** THIS SUBROUTINE DELETES DATA POINTS FROM THE X-BAR, R, AND S CHARTS
C
SUBROUTINE DELXRS(A, B, NS, AS, BS, MENU1)
    DIMENSION A(30), B(30)
    WRITE(5, *) 'ENTER THE TOTAL NUMBER OF SUBGROUPS TO BE
1 DELETED'
    READ(5, *) ND
    NNS=NS-ND
    BS=BS*NS
    AS=AS*NS
    DO 10 I=1, ND
        WRITE(5, *) 'ENTER SUBGROUP NUMBER TO BE DELETED'
        READ(5, *) K
        AS=AS-A(K)
        BS=BS-B(K)
    10 CONTINUE
    AS=AS/NNS
    BS=BS/NNS
    RETURN
END

```

C*** THIS SUBROUTINE DELETES DATA POINTS FROM THE P AND U CONTROL CHARTS

```
C
SUBROUTINE DELPU(A,AB,B,N)
DIMENSION A(30),B(30)
WRITE(3,*) 'ENTER THE TOTAL # OF PAIRS OF DATA POINTS
1 TO BE DELETED'
READ(3,*) ND
TLS=0.0
DO 5 I=1,N
  TLS=TLS+B(I)
5 CONTINUE
AB=AB/TLS
DO 10 I=1,ND
  WRITE(3,*) 'ENTER DATA POINT # TO BE ELIMINATED'
  READ(3,*) K
  AB=AB-A(K)
  TLS=TLS-B(K)
10 CONTINUE
AB=AB/TLS
RETURN
END
```

C*** THIS SUBROUTINE DELETES POINTS FROM THE C AND NP CONTROL CHARTS

```
C
SUBROUTINE DELCNP(A,AB,BB,N,LS)
DIMENSION A(30)
WRITE(3,*) 'ENTER THE TOTAL # OF DATA POINTS TO BE DELETED'
READ(3,*) ND
NNS=N-ND
AB=AB*N
DO 10 I=1,N
  WRITE(3,*) 'ENTER DATA POINT # TO BE DELETED'
  READ(3,*) K
  AB=AB-A(K)
10 CONTINUE
BB=AB/(NNS*LS)
AB=AB/NNS
RETURN
END
```

C*** THIS SUBROUTINE PRINTS A HISTOGRAM TO THE SCREEN
AND TO AN OUTPUT FILE

```
C
SUBROUTINE HISTO(D,NS,SS,*)
DIMENSION D(30,10),KCOUNT(20),NCOUNT(20),NCOORD(12)
DIMENSION CH(20)
INTEGER SS,C2
CHARACTER*65 COL,DASH
CHARACTER*70 LONG
WRITE(3,*) ' ' MENU'
WRITE(3,*) '1) PRINT HISTOGRAM TO SCREEN'
WRITE(3,*) '2) PRINT HISTOGRAM TO FILE'
WRITE(3,*) '3) BOTH'
READ(3,*) MENUH
DMAX=D(1,1)
DMIN=D(1,1)
DO 20 I=1,NS
  DO 10 J=1,SS
    IF(D(I,J).LT.DMIN) DMIN=D(I,J)
    IF(D(I,J).GT.DMAX) DMAX=D(I,J)
10 CONTINUE
20 CONTINUE
DO 25 I=1,65
  COL(I:1)=' '
  DASH(I:1)='-'
25 CONTINUE
WRITE(3,*) ' '
WRITE(3,*) 'INPUT # OF CELL INTERVALS (<=20)'
READ(3,*) C2
CI=(DMAX-DMIN)/C2
DO 30 J=1,C2
  KCOUNT(J)=0.0
30 CONTINUE
DO 40 I=1,NS
  DO 35 K=1,SS
    J=INT((D(I,K)-DMIN)/CI)+1.0
    IF(J.GT.20) J=20
    KCOUNT(J)=KCOUNT(J)+1.0
35 CONTINUE
40 CONTINUE
KMAX=0
DO 45 I=1,C2
```

```

      IF(KCOUNT(I).GT.KMAX) KMAX=KCOUNT(I)
45  CONTINUE
      IF(MENUN.EQ.2) GO TO 90
      NDUM=KMAX/20+1
      FACTOR=NDUM
      DO 50 I=1,20
        NCOUNT(I)=(KCOUNT(I)+.5)/FACTOR
50  CONTINUE
      WRITE(5,55)
85  FORMAT('1',20X,'HISTOGRAM')
      DO 60 I=20,1,-1
        LONG(I:1)=' '
        DO 60 K=2,70
          LONG(K:K)=' '
60  CONTINUE
      IPT=3
      DO 65 J=1,20
        IF(I.GT.NCOUNT(J)) THEN
          IPT=IPT+3
        ELSE
          LONG(IPT:IPT)='*'
          IPT=IPT+1
          LONG(IPT:IPT)='*'
          IPT=IPT+2
        ENDIF
65  CONTINUE
      IID=FACTOR*I
      IF(MOD(I,5).EQ.0) THEN
        WRITE(5,70) IID,LONG
70  FORMAT(' ',15,A70)
      ELSE
        WRITE(5,75) LONG
75  FORMAT(' ',5X,A70)
      ENDIF
80  CONTINUE
      WRITE(5,85) DASH(1:65)
85  FORMAT(' ',5X,A65)
      WRITE(5,9) 'PRESS 1 TO CONTINUE'
      READ(5,*) ND
      IF(MENUN.EQ.1) GO TO 150
C
C*** PRINT HISTOGRAM TO OUTPUT FILE
C
90  WRITE(2,95)
95  FORMAT('1',30X,'HISTOGRAM',/)
      WRITE(2,100)
100  FORMAT('0',30X,'FREQUENCY')
      WRITE(2,105)
105  FORMAT(' ',CELL MIDPT.)
      DASH(1:1)='+'
      DASH(65:65)='+'
      WRITE(2,110) DASH(1:65)
110  FORMAT(12X,65A)
      NDUM=KMAX/60+1
      FACTOR=NDUM
      DO 135 I=1,62
        K=(KCOUNT(I)+.5)/FACTOR
        CM(I)=DMIN+(2.0*(I-1)+1.0)*CI/2.0
        IF(K.EQ.0) THEN
          WRITE(2,115) CM(I)
115  FORMAT(12X,'.'/',F10.2,1X,'.'/12X,'.')
        ELSE
          WRITE(2,120) COL(1:K)
          FORMAT(12X,A)
          WRITE(2,125) CM(I),COL(1:K)
          FORMAT(' ',F10.2,1X,A)
          WRITE(2,120) COL(1:K)
          WRITE(2,130)
130  FORMAT(12X,'+')
        ENDIF
135  CONTINUE
      WRITE(2,120) ' '
      WRITE(2,120) DASH(1:65)
      DO 140 I=1,12
        NCOORD(I)=I*FACTOR+5
140  CONTINUE
      WRITE(2,145) (NCOORD(I),I=1,12)
145  FORMAT(12X,12I5)
150  RETURN 1
      END
C
C*** THIS SUBROUTINE CALCULATES X-BAR, THE RANGE OR THE
C*** STANDARD DEVIATION FOR EACH SUBGROUP AND ALSO

```

```

C*** X-DOUBLE BAR, R-BAR, AND S-BAR
C
SUBROUTINE CRDXRS(D, NS, SS, A1, A2, A1B, A2B, MENU1)
DIMENSION D(30, 10), A1(30), A2(30)
INTEGER SS
A1B=0.0
A2B=0.0
IF(MENU1.EQ.1) THEN
DO 20 I=1, NS
A1(I)=0.0
XHI=D(I, 1)
XLO=D(I, 10)
DO 10 J=1, SS
A1(I)=A1(I)+D(I, J)
IF(D(I, J).LT.XLO) XLO=D(I, J)
IF(D(I, J).GT.XHI) XHI=D(I, J)
10 CONTINUE
A1(I)=A1(I)/SS
A1B=A1B+A1(I)
A2(I)=XHI-XLO
A2B=A2B+A2(I)
20 CONTINUE
A1B=A1B/NS
A2B=A2B/NS
ELSE
DO 30 I=1, NS
A1(I)=0.0
DO 30 J=1, SS
A1(I)=A1(I)+D(I, J)
30 CONTINUE
A1(I)=A1(I)/SS
A1B=A1B+A1(I)
A2(I)=0.0
DO 40 J=1, SS
A2(I)=(D(I, J)-A1(I))*2+A2(I)
40 CONTINUE
A2(I)=SQRT(A2(I)/(SS-1))
A2B=A2B+A2(I)
50 CONTINUE
A1B=A1B/NS
A2B=A2B/NS
ENDIF
RETURN
END
C
C*** THIS SUBROUTINE CALCULATES THE FRACTION REJECTED OR
C*** NONCONFORMITIES PER UNIT FOR EACH DATA PAIR AND
C*** THE AVERAGE FRACTION REJECTED AND THE AVERAGE
C*** NONCONFORMITY PER UNIT
C
SUBROUTINE CRDPU(CD1, CD2, N, MENU1, CDB, CDBB, MENP, ALS, MENU2)
DIMENSION CD1(30), CD2(30), CDB(30)
CDBB=0.0
CR=0.0
CN=0.0
DO 20 I=1, N
CDB(I)=0.0
CDB(I)=CD1(I)/CD2(I)
CR=CR+CD1(I)
CN=CN+CD2(I)
20 CONTINUE
CDBB=CR/CN
IF(MENU2.EQ.1) GO TO 40
IF(MENU1.EQ.4) THEN
WRITE(5, *) 'DO YOU WISH TO USE'
WRITE(5, *) '1) INDIVIDUAL LOT SIZES'
WRITE(5, *) '2) ESTIMATED AVERAGE LOT SIZE'
WRITE(5, *) '3) CALCULATED AVERAGE LOT SIZE'
READ(5, *) MENP
IF(MENP.EQ.2) THEN
WRITE(5, *) 'ENTER ESTIMATED AVERAGE LOT SIZE'
READ(5, *) ALS
ELSEIF(MENP.EQ.3) THEN
DO 30 I=1, N
ALS=ALS+CD2(I)
30 CONTINUE
ALS=ALS/N
ENDIF
ENDIF
40 RETURN
END
C
C*** THIS SUBROUTINE CALCULATES THE AVERAGE NUMBER REJECTED AND AVERAGE

```

C*** FRACTION REJECTED OR THE AVERAGE NUMBER OF NONCONFORMITIES.

```
C
SUBROUTINE CRDNPC(CRD,N,LS,CNB,CPB)
DIMENSION CRD(30)
CNB=0.0
DO 10 I=1,N
  CNB=CNB+CRD(I)
10 CONTINUE
CNB=CNB/N
IF(LS.NE.0) CPB=CNB/LS
RETURN
END
```

C
C*** THIS SUBROUTINE ALLOWS THE USER TO ADD NEW SUBGROUPS TO
C*** THE EXISTING DATA FILE

```
C
SUBROUTINE ADDXRS(D,NS,SS,NFILE,*)
DIMENSION D(30,10)
INTEGER SS
CHARACTER*10 NFILE
WRITE(5,*) 'ENTER THE NUMBER OF SUBGROUPS TO BE
1 ADDED'
READ(5,*) NA
NT=NA+NS
IF(NT.GT.30) THEN
  ND=NT-30
  DO 20 I=1,NS-ND
    DO 10 J=1,SS
      D(I,J)=D(ND+I,J)
10 CONTINUE
20 CONTINUE
  NN=NS-ND+1
  NS=30
ELSE
  NN=NS+1
  NS=NS+NA
ENDIF
DO 40 I=NN,NS
  K=I-(NN-1)
  WRITE(5,30) K
30 FORMAT(' ', 'ENTER SUBGROUP # ',12, ' TO BE ADDED')
  READ(5,*) (D(I,J),J=1,SS)
40 CONTINUE
CLOSE(UNIT=1,STATUS='DELETE')
OPEN(UNIT=1,NAME=NFILE,STATUS='NEW')
WRITE(1,*) ((D(I,J),J=1,SS),I=1,NS)
RETURN 1
END
```

C
C*** THIS SUBROUTINE ALLOWS THE USER TO ADD DATA POINTS
C*** TO THE EXISTING DATA FOR A C OR NP CONTROL CHART

```
C
SUBROUTINE ADDCNP(A,N,NFILE,*)
DIMENSION A(30)
CHARACTER*10 NFILE
WRITE(5,*) 'ENTER THE # OF DATA POINTS TO BE ADDED'
READ(5,*) NA
NT=NA+N
IF(NT.GT.30) THEN
  ND=NT-30
  DO 10 I=1,N-ND
    A(I)=A(ND+I)
10 CONTINUE
  NN=N-ND+1
  N=30
ELSE
  NN=N+1
  N=N+NA
ENDIF
DO 30 I=NN,N
  K=I-(NN-1)
  WRITE(5,20) K
20 FORMAT(' ', 'ENTER DATA POINT # ',12, ' TO BE ADDED')
  READ(5,*) A(I)
30 CONTINUE
CLOSE(UNIT=1,STATUS='DELETE')
OPEN(UNIT=1,NAME=NFILE,STATUS='NEW')
DO 40 I=1,N
  WRITE(1,*) A(I)
40 CONTINUE
RETURN 1
END
```

C

```

C*** THIS SUBROUTINE ALLOWS THE USER TO ADD DATA POINTS
C*** TO THE EXISTING DATA FOR A P OR U CHART
C
      SUBROUTINE ADDPU(A,B,N,MENU1,NFILE,*)
      DIMENSION A(30),B(30)
      CHARACTER*10 NFILE
      WRITE(5,*) 'ENTER THE # OF PAIRS OF DATA POINTS TO BE
1  ADDED'
      READ(5,*) NA
      NT=NA+N
      IF(NT.GT.30) THEN
        ND=NT-30
        DO 10 I=1,N-ND
          A(I)=A(ND+I)
          B(I)=B(ND+I)
10       CONTINUE
        NN=N-ND+1
        N=30
      ELSE
        NN=N+1
        N=N+NA
      ENDIF
      DO 40 I=NN,N
        IF(MENU1.EQ.3) THEN
          WRITE(5,20)
          FORMAT(' ', 'ENTER # OF NONCONFORMITIES AND UNITS
20  PRODUCED')
        ELSE
          WRITE(5,30)
          FORMAT(' ', 'ENTER # OF REJECTS & # INSPECTED')
30       CONTINUE
        ENDIF
        READ(5,*) A(I),B(I)
40       CONTINUE
      CLOSE(UNIT=1, STATUS='DELETE')
      OPEN(UNIT=1, NAME=NFILE, STATUS='NEW')
      IF(MENU1.EQ.3) THEN
        DO 50 I=1,N
          WRITE(1,*) A(I),B(I)
50       CONTINUE
      ELSE
        DO 60 I=1,N
          WRITE(1,*) B(I),A(I)
60       CONTINUE
      ENDIF
      RETURN 1
      END

C*** THIS SUBROUTINE WRITES A HARDCOPY OF THE RAW DATA
C*** AND THE POINTS TO BE PLOTTED FOR AN X-BAR, R, OR S
C*** CONTROL CHART
C
      SUBROUTINE HCDXRS(D,NS,SS,A,B,MENU1,*)
      DIMENSION D(30,10),A(30),B(30)
      INTEGER SS
      WRITE(2,10)
10     FORMAT('1', ///, 35X, 'SUBGROUP DATA', //, '0', 1X, 'SGN', 33X,
1  'RAW DATA', ///)
      DO 20 I=1,NS
        WRITE(2,15) I, (D(I,J), J=1, SS)
15     FORMAT(' ', 1X, 12, 2X, 10(1X, F6.2))
20     CONTINUE
      IF(MENU1.EQ.1) THEN
        WRITE(2,30)
        FORMAT('1', ///, 35X, 'SUBGROUP DATA', ///, 33X, 'XBAR',
1  'RANGE', ///)
        DO 30 I=1,NS
          WRITE(2,40) A(I),B(I)
          FORMAT(' ', 28X, F9.4, 5X, F9.4)
30       CONTINUE
      ELSE
        WRITE(2,60)
        FORMAT('1', ///, 35X, 'SUBGROUP DATA', ///, 33X, 'XBAR',
1  'S', ///)
        DO 60 I=1,NS
          WRITE(2,70) A(I),B(I)
          FORMAT(' ', 28X, F9.4, 5X, F9.4)
70       CONTINUE
80     CONTINUE
      ENDIF
      RETURN 1
      END

C*** THIS SUBROUTINE WRITES A HARDCOPY OF THE RAW DATA AND
C*** THE POINTS TO BE PLOTTED FOR A C OR A NP CONTROL CHART

```

```

C
SUBROUTINE HCDCNF(NMD,NDP,LS,*)
REAL NMD(30)
IF(LS.EQ.0) THEN
  WRITE(2,10)
10  FORMAT('1',///,32X,'DATA SET FOR C-CHART')
  WRITE(2,20)
20  FORMAT(///,38X,'NUMBER',/40X,'OF',/34X,'NONCONFORMITIES'
  //)
  DO 30 I=1,NDP
    WRITE(2,25) NMD(I)
    FORMAT(37X,F7.2)
  30  CONTINUE
ELSE
  WRITE(2,40)
  FORMAT('1',///,32X,'DATA SET FOR NP-CHART')
  WRITE(2,45)
45  FORMAT('0',/34X,'LOT',8X,'NUMBER',/33X,'SIZE',
  7X,'REJECTED',//)
  DO 55 I=1,NDP
    WRITE(2,50) LS,NMD(I)
    FORMAT(' ',33X,I4,7X,F7.2)
  55  CONTINUE
ENDIF
RETURN 1
END

C
C*** THIS SUBROUTINE WRITES A HARDCOPY OF THE RAW DATA AND
C*** THE POINTS TO BE PLOTTED FOR A P AND U CHART.
C
SUBROUTINE HCDPU(NMD,MMD2,MMD1,NDP,MENU1,*)
DIMENSION MMD(30),MMD2(3),MMD1(30)
IF(MENU1.EQ.3) THEN
  WRITE(2,10)
10  FORMAT('1',///,32X,'DATA SET FOR U-CHART')
  WRITE(2,20)
20  FORMAT(///,19X,'NUMBER',14X,'NUMBER',8X,
  'NONCONFORMITIES',/20X,'OF',15X,'OF UNITS',
  13X,'PER',/14X,'NONCONFORMITIES',8X,'PRODUCED',
  12X,'UNIT',//)
  DO 40 I=1,NDP
    WRITE(2,30) MMD2(I),MMD(I),MMD1(I)
    FORMAT(' ',16X,F7.2,13X,F7.2,10X,F9.4)
  40  CONTINUE
ELSE
  WRITE(2,50)
  FORMAT('1',///,32X,'DATA SET FOR P-CHART')
  WRITE(2,60)
60  FORMAT(///,25X,'NUMBER',10X,'NUMBER',10X,'FRACTION',
  12X,'INSPECTED',7X,'REJECTED',10X,'REJECTED',//)
  DO 80 I=1,NDP
    WRITE(2,70) MMD2(I),MMD(I),MMD1(I)
    FORMAT(' ',23X,F7.2,8X,F7.2,9X,F9.4)
  80  CONTINUE
ENDIF
RETURN 1
END

C
C*** THIS SUBROUTINE CALCULATES THE CONTROL LIMITS FOR A X-BAR,
C*** R, OR S CONTROL CHART
C
SUBROUTINE CLXRS(MENU1,MENU2,XBB,SS,NS,SS,UCL,LCL,CL,NFILE)
DIMENSION A2(10),A1(10),D4(10),D3(10),B4(10),B3(10)
DIMENSION D2(10),D1(10),SD2(10),B2(10),B1(10),C2(10)
INTEGER SS
REAL LCL
CHARACTER*10 NFILE
DATA A2/0.0,1.88,1.02,.73,.58,.48,.42,.37,.34,.31/
DATA A1/0.0,3.76,2.39,1.88,1.60,1.41,1.28,1.17,1.09,1.03/
DATA D4/0.0,3.27,2.57,2.28,2.11,2.00,1.92,1.86,1.82,1.78/
DATA D3/0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0/
DATA B4/0.0,3.27,2.57,2.27,2.09,1.97,1.88,1.81,1.76,1.72/
DATA B3/0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0/
DATA D2/0.0,3.69,4.36,4.70,4.92,5.08,5.2,5.31,5.39,5.47/
DATA D1/0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0/
DATA SD2/0.0,1.128,1.693,2.059,2.326,2.534,2.704,2.847,
  2.970,3.078/
DATA B2/0.0,1.84,1.86,1.81,1.76,1.71,1.67,1.64,1.61,1.58/
DATA B1/0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0/
DATA C2/0.0,.5642,.7236,.7979,.8407,.8686,.8862,.9027,
  .9159,.9227/
WRITE(3,*) ' ' MENU'
WRITE(3,*) ' '

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WRITE(5,*) '1) CONTROL LIMITS CALCULATED FROM DATA'
WRITE(5,*) '2) USE OLD CONTROL LIMITS'
WRITE(5,*) '3) USE AIMED AT VALUES'
READ(5,*) MENCL
IF(MENCL.EQ.1) THEN
  IF(MENU2.EQ.3) THEN
    IF(MENU1.EQ.1) THEN
      UCL=XBB+A2(SS)*SB
      LCL=XBB-A2(SS)*SB
      CL=XBB
    ELSEIF(MENU1.EQ.2) THEN
      Y=(NS-1.)/NS
      UCL=XBB+SQRT(Y)*A1(SS)*SB
      LCL=XBB-SQRT(Y)*A1(SS)*SB
      CL=XBB
    ENDIF
  ELSEIF(MENU2.EQ.4.AND.MENU1.EQ.1) THEN
    UCL=D4(SS)*SB
    LCL=D3(SS)*SB
    CL=SB
  ELSEIF(MENU2.EQ.4.AND.MENU1.EQ.2) THEN
    UCL=B4(SS)*SB
    LCL=B3(SS)*SB
    CL=SB
  ENDIF
ELSEIF(MENCL.EQ.2) THEN
  IF(MENU2.EQ.3) THEN
    OPEN(UNIT=3,FILE=NFILE,STATUS='OLD')
    READ(3,*) UCL,LCL,CL
    CLOSE(UNIT=3,STATUS='KEEP')
  ELSEIF(MENU2.EQ.4) THEN
    OPEN(UNIT=4,FILE=NFILE,STATUS='OLD')
    READ(4,*) UCL,LCL,CL
    CLOSE(UNIT=4,STATUS='KEEP')
  ENDIF
ELSEIF(MENCL.EQ.3) THEN
  IF(MENU2.EQ.3) THEN
    WRITE(5,*) 'ENTER AIMED AT VALUES FOR XBAR AND
1 SIGMA'
    READ(5,*) XB,SIG
    Y=REAL(NS)
    UCL=XB+(3/SQRT(Y))*SIG
    LCL=XB-(3/SQRT(Y))*SIG
    CL=XB
  ELSEIF(MENU2.EQ.4) THEN
    WRITE(5,*) 'ENTER AIMED AT VALUE OF SIGMA'
    READ(5,*) SIG
    IF(MENU1.EQ.1) THEN
      UCL=D2(SS)*SIG
      LCL=D1(SS)*SIG
      CL=SD2(SS)*SIG
    ELSE
      Y=(NS-1.)/NS
      UCL=B2(SS)*SIG*SQRT(Y)
      LCL=B1(SS)*SIG*SQRT(Y)
      CL=C2(SS)*SIG*SQRT(Y)
    ENDIF
  ENDIF
ENDIF
RETURN
END
C
C*** THIS SUBROUTINE CALCULATES THE CONTROL LIMITS FOR A
C*** P (AVERAGE LOT SIZE), NP, OR C CONTROL CHART
C
SUBROUTINE CLPNPC(MENU1,MNP,AP,AN,UCL,LCL,CL,NFILE)
REAL LCL
CHARACTER*10 NFILE
WRITE(5,*) ' ' MENU'
WRITE(5,*) ' '
WRITE(5,*) '1) CONTROL CHARTS CALCULATED FROM DATA'
WRITE(5,*) '2) USE OLD CONTROL LIMITS'
WRITE(5,*) '3) USE AIMED AT VALUES'
READ(5,*) MENCL
IF(MENCL.EQ.3) THEN
  IF(MENU1.EQ.4) THEN
    WRITE(5,*) 'ENTER AIMED AT VALUE OF P-PRIME'
  ELSEIF(MENU1.EQ.3) THEN
    WRITE(5,*) 'ENTER AIMED AT VALUE OF C-PRIME'
  ENDIF
  READ(5,*) AP
ENDIF
IF(MENCL.EQ.1.OR.MENCL.EQ.3) THEN

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      IF(MENU1.EQ.4) THEN
        IF(MNP.EQ.1) THEN
          UCL=AP+3*SQRT((AP*(1-AP))/AN)
          LCL=AP-3*SQRT((AP*(1-AP))/AN)
          CL=AP
        ELSE
          UCL=AN+3*SQRT(AN*(1-AP))
          LCL=AN-3*SQRT(AN*(1-AP))
          CL=AN
        ENDIF
      ELSEIF(MENU1.EQ.3) THEN
        UCL=AP+3*SQRT(AP)
        LCL=AP-3*SQRT(AP)
        CL=AP
      ENDIF
    ELSE
      OPEN(UNIT=3, FILE=NFILE, STATUS='OLD')
      READ(3,*) UCL,LCL,CL
      CLOSE(UNIT=3, STATUS='KEEP')
    ENDIF
    RETURN
  END

C
C*** THIS SUBROUTINE CALCULATES THE CONTROL LIMITS FOR A
C*** P (INDIVIDUAL LOT SIZES) OR U CHART
C
  SUBROUTINE CLPU(MENU1,N,NV,AP,VUCL,VLCL,CL)
    DIMENSION VUCL(30),VLCL(30)
    REAL NV(30)
    WRITE(5,*) '          MENU'
    WRITE(5,*) '1) CONTROL CHARTS CALCULATED FROM DATA'
    WRITE(5,*) '2) USE AIMED AT VALUE FOR CENTRAL LINE'
    READ(5,*) MENCHL
    IF(MENCHL.EQ.2) THEN
      IF(MENU1.EQ.3) THEN
        WRITE(5,*) 'ENTER AIMED AT VALUE FOR U-PRIME'
      ELSE
        WRITE(5,*) 'ENTER AIMED AT VALUE FOR P-PRIME'
      ENDIF
    ENDIF
    READ(5,*) AP
  ENDIF
  IF(MENU1.EQ.3) THEN
    DO 10 I=1,N
      VUCL(I)=AP+3*SQRT(AP/NV(I))
      VLCL(I)=AP-3*SQRT(AP/NV(I))
      IF(VLCL(I).LT.0.0) VLCL(I)=0.0
    10  CONTINUE
    CL=AP
  ELSE
    DO 20 I=1,N
      VUCL(I)=AP+3*SQRT(AP*(1-AP)/NV(I))
      VLCL(I)=AP-3*SQRT(AP*(1-AP)/NV(I))
      IF(VLCL(I).LT.0.0) VLCL(I)=0.0
    20  CONTINUE
    CL=AP
  ENDIF
  RETURN
  END

C
C*** THIS SUBROUTINE PRINTS X-BAR, R, S, P (AVERAGE LOT SIZES), NP,
C*** AND C CONTROL CHARTS TO THE SCREEN OR TO AN OUTPUT FILE
C
  SUBROUTINE CHART(A,UCL,LCL,CL,N,NFILE,MENU1,MENU2,MNP,MCU,*)
    DIMENSION A(30),NB(30)
    REAL LCL
    INTEGER SS
    CHARACTER*10 NFILE
    CHARACTER*70 LINE
    CHARACTER*1 POINT
    WRITE(5,*) '          MENU'
    WRITE(5,*) '1) CONTROL CHART TO FILE'
    WRITE(5,*) '2) CONTROL CHART TO SCREEN'
    WRITE(5,*) '3) BOTH'
    READ(5,*) MENCH
    IF(MENCH.EQ.2) GO TO 125
    IF((MENU1.EQ.1.OR.MENU1.EQ.2).AND.MENU2.EQ.3) THEN
      WRITE(2,10)
      10  FORMAT('1',35X,'X-BAR CHART')
    ELSEIF(MENU1.EQ.1.AND.MENU2.EQ.4) THEN
      WRITE(2,20)
      20  FORMAT('1',35X,'RANGE CHART')

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ELSEIF(MENU1.EQ.2.AND.MENU2.EQ.4) THEN
WRITE(2,30)
30  FORMAT('1',37X,'S CHART')
ELSEIF(MENU1.EQ.4.AND.MNP.EQ.1) THEN
WRITE(2,40)
40  FORMAT('1',37X,'P CHART')
ELSEIF(MENU1.EQ.4.AND.MNP.EQ.2) THEN
WRITE(2,50)
50  FORMAT('1',37X,'NP CHART')
ELSEIF(MENU1.EQ.3.AND.MCU.EQ.1) THEN
WRITE(2,60)
60  FORMAT('1',37X,'C CHART')
ENDIF
IF(LCL.LT.0.0) THEN
WRITE(2,70)
70  FORMAT('0',64X,'U'/40X,'C',24X,'C'/40X,'L',24X,
1  'L'/)
75  WRITE(2,75) CL,UCL
FORMAT(/36X,F9.4,16X,F9.4/40X,' ',24X,' ')
ELSE
WRITE(2,80)
80  FORMAT('0',14X,'L',49X,'U'/15X,'C',24X,'C',24X,'C'/15X,'L',
1  24X,'L',24X,'L'/)
90  WRITE(2,90) LCL,CL,UCL
FORMAT(11X,F9.4,16X,F9.4,16X,F9.4/15X,' ',24X,' ',24X,' ')
ENDIF
WRITE(2,95)
95  FORMAT(3X,72(' '))
DO 115 I=1,N
LINE=
IF(LCL.LT.0.0) GO TO 96
LINE(10:10)=
96  LINE(35:35)=
LINE(60:60)=
100 WRITE(2,100) LINE
FORMAT(5X,' ',A70,' ')
LINE(10:10)=
LINE(60:60)=
J=((49*A(I)+UCL-50*LCL)/(UCL-LCL))+.5
J=J+9
IF(J.LT.1) J=1
IF(J.GT.70) J=70
IF(J.LT.10.OR.J.GT.60) THEN
LINE(J:J)='7'
ELSE
LINE(J:J)='*'
ENDIF
ENDIF
WRITE(2,110) I,LINE
110  FORMAT(2X,I2,'-',',',A70,' ')
115 CONTINUE
WRITE(2,120)
120  FORMAT(3X,72(' '))
IF(MENCH.EQ.1) GO TO 260
125 IF((MENU1.EQ.1.OR.MENU1.EQ.2).AND.MENU2.EQ.3) THEN
WRITE(3,*) 'X-BAR CHART'
ELSEIF(MENU1.EQ.1.AND.MENU2.EQ.4) THEN
WRITE(3,*) 'RANGE CHART'
ELSEIF(MENU1.EQ.2.AND.MENU2.EQ.4) THEN
WRITE(3,*) 'S CHART'
ELSEIF(MENU1.EQ.4.AND.MNP.EQ.1) THEN
WRITE(3,*) 'P CHART'
ELSEIF(MENU1.EQ.4.AND.MNP.EQ.2) THEN
WRITE(3,*) 'NP CHART'
ELSEIF(MENU1.EQ.3.AND.MCU.EQ.1) THEN
WRITE(3,*) 'C CHART'
ENDIF
DO 210 I=1,N
NB(I)=((16*A(I)+UCL-17*LCL)/(UCL-LCL))+.5
NB(I)=NB(I)+1
IF(NB(I).LT.1) NB(I)=1
IF(NB(I).GT.19) NB(I)=19
210 CONTINUE
DO 250 I=19,1,-1
DO 215 J=1,70
LINE(J:J)=
215 CONTINUE
IF(I.EQ.10) THEN
DO 220 J=1,70
LINE(J:J)='-'
220 CONTINUE
ELSEIF(I.EQ.2.OR.I.EQ.18) THEN
IF(I.EQ.2.AND.LCL.LT.0.0) GO TO 227
DO 225 J=1,70,2

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225     LINE(J:J)='-'
        CONTINUE
227     ENDIF
        POINT='*'
        IF(I.EQ.19.OR.I.EQ.1) POINT='?'
        DO 230 J=1,N
230     IF(I.EQ.NB(J)) LINE(J*2:J*2)=POINT
        CONTINUE
        IF(I.EQ.18) THEN
240     WRITE(5,240) UCL,LINE
            FORMAT(' ',F8.4,'-',',',A61)
        ELSEIF(I.EQ.10) THEN
            WRITE(5,240) CL,LINE
        ELSEIF(I.EQ.2) THEN
            IF(LCL.LT.0.0) GO TO 250
            WRITE(5,240) LCL,LINE
        ELSE
245     WRITE(5,245) LINE
            FORMAT(' ',10X,'-',',A61)
        ENDIF
250     CONTINUE
260     WRITE(5,*) 'ENTER 1 TO SAVE THESE CONTROL LIMITS'
        WRITE(5,*) 'ENTER 2 TO CONTINUE'
        READ(5,*) NSCL
        IF(NSCL.EQ.1) THEN
            IF(MENU1.EQ.1.OR.MENU2.EQ.2).AND.MENU2.EQ.4) THEN
                NU=4
            ELSE
                NU=3
            ENDIF
            OPEN(UNIT=NU,FILE=NFILE,STATUS='UNKNOWN')
            CLOSE(UNIT=NU,STATUS='DELETE')
            OPEN(UNIT=NU,FILE=NFILE,STATUS='NEW')
            WRITE(NU,*) UCL,LCL,CL
            CLOSE(UNIT=NU,STATUS='KEEP')
        ENDIF
        RETURN 1
    END
C
C*** THIS SUBROUTINE PRINTS P (INDIVIDUAL LOT SIZES) OR U
C*** CONTROL CHARTS
C
    SUBROUTINE UCHART(A,VUCL,VLCL,CL,N,MENU1,*)
    DIMENSION A(30),VUCL(30),VLCL(30),NA(30),NB(30),NC(30)
    CHARACTER*10 NFILE
    CHARACTER*70 LINE
    CHARACTER*1 POINT
    WRITE(5,*) ' '
    WRITE(5,*) ' '
    WRITE(5,*) '1) CONTROL CHART TO FILE'
    WRITE(5,*) '2) CONTROL CHART TO SCREEN'
    WRITE(5,*) '3) BOTH'
    READ(5,*) MENCH
    XHI=VUCL(1)
    XLO=VLCL(1)
    DO 5 I=1,N
        IF(VUCL(I).GT.XHI) XHI=VUCL(I)
        IF(VLCL(I).LT.XLO) XLO=VLCL(I)
    5 CONTINUE
    IF(MENCH.EQ.2) GO TO 90
    IF(MENU1.EQ.3) THEN
        WRITE(2,10)
        FORMAT('1',37X,'U CHART')
    ELSE
        WRITE(2,20)
        FORMAT('1',37X,'P CHART')
    ENDIF
    WRITE(2,30) CL
    FORMAT('0',33X,'CL = ',F9.4, '/')
    WRITE(2,40)
    FORMAT(5X,72(' '))
    J=((49*CL+XHI-50*XLO)/(XHI-XLO))+.5
    J=J+.9
    DO 70 I=1,N
        LINE=
        K=((49*A(I)+XHI-50*XLO)/(XHI-XLO))+.5
        K=K+.9
        L=((49*VUCL(I)+XHI-50*XLO)/(XHI-XLO))+.5
        L=L+.9
        M=((49*VLCL(I)+XHI-50*XLO)/(XHI-XLO))+.5
        M=M+.9
        LINE(J:J)=' '
        LINE(L:L)=' '
    70 CONTINUE

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LINE(M:M)=' '
IF(K.LT.1) K=1
IF(K.GT.70) K=70
IF(K.LT.M.OR.K.GT.L) THEN
    LINE(K:K)='?'
ELSE
    LINE(K:K)='*'
ENDIF
WRITE(2,50) I,LINE
30  FORMAT(2X,12,'-',',',A70,' ')
    LINE(K:K)=' '
    IF(K.EQ.J.OR.K.EQ.L.OR.K.EQ.M) LINE(K:K)='!'
    WRITE(2,60) LINE
60  FORMAT(5X,' ',A70,' ')
70  CONTINUE
    WRITE(2,80)
    FORMAT(5X,72(' '))
    IF(MENCH.EQ.1) GO TO 160
    IF(MENUL.EQ.3) THEN
        WRITE(5,*) ' U CHART'
    ELSE
        WRITE(5,*) ' P CHART'
    ENDIF
    ND=((16*CL+XHI-17*XLO)/(XHI-XLO))+1.5
    DO 110 I=1,N
        NA(I)=((16*A(I)+XHI-17*XLO)/(XHI-XLO))+1.5
        NB(I)=((16*VUCL(I)+XHI-17*XLO)/(XHI-XLO))+1.5
        NC(I)=((16*VLCL(I)+XHI-17*XLO)/(XHI-XLO))+1.5
        IF(NA(I).LT.1) NA(I)=1
        IF(NA(I).GT.19) NA(I)=19
110  CONTINUE
    DO 150 I=19.1,-1
        DO 115 J=1,70
            LINE(J:J)=' '
115  CONTINUE
        IF(I.EQ.ND) THEN
            DO 117 J=1,70
                LINE(J:J)='-'
117  CONTINUE
            ENDIF
            DO 120 J=1,N
                IF(I.EQ.NB(J).OR.I.EQ.NC(J)) THEN
                    LINE(J*2:J*2)='-'
                    LINE(J*2+1:J*2+1)='-'
                ENDIF
                POINT='*'
                IF(NA(J).LT.NC(J).OR.NA(J).GT.NB(J)) POINT='?'
                IF(I.EQ.NA(J)) LINE(J*2+1:J*2+1)=POINT
120  CONTINUE
            IF(I.EQ.ND) THEN
                WRITE(5,130) CL,LINE
130  FORMAT(' ',F9.4,'-',',',A61)
            ELSE
                WRITE(5,140) LINE
140  FORMAT(' ',10X,' ',A61)
            ENDIF
150  CONTINUE
        WRITE(5,*) 'ENTER 1 TO CONTINUE'
        READ(5,*) NK
160  RETURN 1
    END

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END

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